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UNITED STATES
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BUREAU OF MINES
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TWO DEVICES TO PREVENT ELECTRIC ARCS WITH AIRDOX OPERATIONS IN COAL MINES

BY

F. J. GALLAGHER

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TWO DEVICES TO PREVENT ELECTRIC ARCS WITH AIRDOX OPERATIONS IN COAL MINES[1]

By F. J. Gallagher[2]

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INTRODUCTION

The purpose of this circular is to present information on the construction and use of reinforced rubber-jacketed tubing and insulating air-line couplings in coal mines where Airdox is used for breaking coal in order to eliminate, insofar as possible, arcing at the face between Airdox tubing and the track or other face equipment.

ACKNOWLEDGMENT

The information given by the W. M. Hales Co., Chicago, Ill., and the Peabody Coal Co., Taylorville, Ill., regarding the construction and use of rubber-jacketed tubing and insulating couplings is gratefully acknowledged.

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[1] Work completed December, 1948. The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7515."

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GENERAL INFORMATION

Since its introduction into coal mines, the use of Airdox has grown in popularity, especially in the Indiana and Illinois coal fields. Its use permits breaking down coal on shift, whereas the use of explosives for blasting coal on shift is prohibited by law in those States. Many of the hazards connected with the use of explosives are eliminated. The accident experience in the use of Airdox has been excellent with respect to the number of fatalities or serious injuries per million tons mined.

The Federal Mine Safety Code specifies that Airdox lines should be grounded at the compressor and at other points of low resistance along the lines but should not be connected to tracks, pipe lines, or other possible power conductors. The majority of operators in the Indiana and Illinois coal mines, in which Airdox is used, approve the precautions embodied in the code regulations

If Airdox lines are grounded in accordance with the Code, the following hazards persist:

1. Generally, in live workings, the track is temporary and usually is constructed of lightweight steel rails and it is not as well maintained as main haulage track. As a result, poor bonding, broken bonds, loose joints, or broken rails are common. Because of such conditions, the track, which ordinarily serves as the return conductor for a direct-current system, frequently will have a potential above ground potential, and it will vary according to the load and how seriously the continuity of the return circuit has been impaired. Such conditions will result in sparking or arcing at the face if the Airdox line or copper tubing near the face contacts the rail or the frames of track-mounted equipment, because generally the compressed-air (Airdox) line is maintained at or near ground potential.

2. A man handling an Airdox shell near the face could sustain an electric shock of varying severity if he were in contact with the track under the conditions mentioned above. Also, a person handling a shell could receive a shock if the Airdox line should accidentally touch the trolley wire.

3. Some investigators believe that electrolysis may occur as a result of stray currents transferring from the track to the pipe line, or vice versa, if the line and track are not bonded together. Airdox lines that have been in service for many years in Indiana and Illinois mines have shown no appreciable effects of electrolysis where an effort has been made to isolate the lines.

4. With trackless equipment, such as rubber-tired and caterpillar-mounted machines, sparking or arcing at the face will occur if an electrical fault occurs in a machine whose frame is not grounded, provided the frame should contact the Airdox copper tubing. However, this could occur whether or not Airdox lines are connected to the track.

If Airdox lines are bonded to the track, the following hazards persist:

1. The lines become part of the electrical return circuit and are, therefore, power conductors. In producing sections of coal mines where track alone is the return conductor, broken bonds, rails, or loose joints may cause air lines to transmit a considerable part of the return current; this is undesirable. Moreover, if a load is on the system inby a broken track, and the break is close to live workings, a man handling a shell will be subject to shock, depending on the division of current and resistance of the material upon which the man is standing.

2. Electrolysis might be enhanced because poor bonding, broken rails, broken bonds, or loose joints will cause variable voltages to be impressed upon the pipe line as well as upon the track. As a result, current might flow from the pipe line to the track, or vice versa, at points where the line contacts a damp floor or roof, which serves as an electrolyte. Possible current transfer to or from the pipe line, dependent on the diversity of loads, will cause deterioration of the pipe by electrolytic action. The action would be rapid if bonding connections between the pipe line and track were loosely made or became loose.

3. Bonding air lines to the track presupposes the installation of such lines on haulage roads, which is hazardous.

Recent development of an insulating coupling and a reinforced rubber-jacketed tubing virtually eliminate arcing at the face and also the possibility of electric shock.

RUBBER-JACKETED TUBING

Reinforced rubber-jacketed tubing has been introduced to supplant the use of copper tubing in face regions. The rubber tubing is manufactured in 50-foot lengths and is used between the Airdox shell and the blow-down valve. To protect the rubber tubing from damage by broken coal, a short copper-tube "pig-tail" is attached to the shell, and copper tubing of varying lengths also is used as a lead from the blow-down valve. The rubber tubing is equipped with 3/8-inch brass male couplings on each end pressed in place by a patented method. The inner side of a coupling sleeve contacts the steel reinforcing in the tubing, which is itself an electrical conductor, but is covered with a well-constructed rubber jacket. A coupling sleeve has a length of approximately 1-3/8 inches, which assures an adequate contact surface. The rubber tubing is coupled to the short lengths of copper tubing from the shell and blow-down valve by "Cardox Emmeto" fittings that have been suitably tested for the service intended. Such an arrangement assures an insulated air-line conductor between the face and 50 feet therefrom. The likelihood of the short copper "pig-tail" contacting rails or equipment at the face is considered remote. When coal is broken with Airdox, no other equipment is at the face, and the copper "pig-tail" is as short as possible. Arcing will occur, however, at the outby end of the rubber tubing where it is coupled to the copper tubing attached to the blow-down valve if it should contact equipment or track with a difference of potential existing between the air line and the track. However, if such arcs occur, they would be 50 feet from the face.

The rubber tubing has an inside diameter of 1/4-inch and an over all diameter of 11/16-inch. The cross section from the inside of the tubing outward is as follows: a synthetic-rubber tube is covered by 1 ply of high tensile-strength steel braid that is covered with 1 ply of synthetic rubber and then another ply of high-tensile steel braid. The outer steel braid is covered with a cotton braiding, and a substantial rubber jacket serves as the outermost covering of the tubing.

The cross section of the rubber tubing and a short piece of the tubing with coupling attached are shown in figure 1.

INSULATING COUPLINGS

At a meeting of the mining-electrical engineers of the Bureau of Mines in Pittsburgh, Pa. in October 1947, it was agreed that to eliminate the hazard of arcing at the face an insulating coupling should be inserted between the copper tubing on the Airdox shell and the air line. Arcs are caused when contact is made between the air line and the track or equipment if the air line and track or other equipment are at different electrical potentials.

A large coal operator in Illinois developed an insulating coupling that has been in service for a considerable time and is giving satisfactory results.

The coupling consists of two 3-1/2- by 3-1/2- by 1-inch machined-steel blocks. The steel blocks are center-drilled with 1-inch holes that are threaded to receive the 1-inch steel-pipe air line. Corner holes 3/4-inch in diameter also are drilled in the blocks, so that they may be bolted together with 5/8-inch machine bolts with hexagon nuts. Insulating bushings, 3/4-inch outside diameter, are used in the bolt holes to insulate the bolts from the steel plates. Three insulating blocks, 3/8-inch thick and 3-1/2 inches square, are used so that the entire face of the steel blocks may be covered.

The outside surface of each steel block is covered with insulating material and a third piece of insulation is inserted between the blocks. The three layers of insulating material are drilled with holes to match the holes in the steel blocks. The center holes in the outside insulating blocks are slightly larger than the holes in the steel blocks to facilitate insertion of the 1-inch pipe line.

The insulation between the steel blocks has a small copper gasket pressed into the material on each side of the center or pipe hole. The gaskets are 7/8-inch in diameter and so set that the pipe may be butted snugly on both sides of the insulator. A small section of insulation remains between the gaskets, so that the two sections of pipe will be insulated from each other. After a coupling is assembled, it is tightly bolted. The insulating bushings are long enough to extend through the steel plates and into the insulating material on both ends of the coupling. A "megger" test on the assembled coupling with short lengths of pipe tightly screwed in place indicated a resistance of 240 megohms between the pipe sections.

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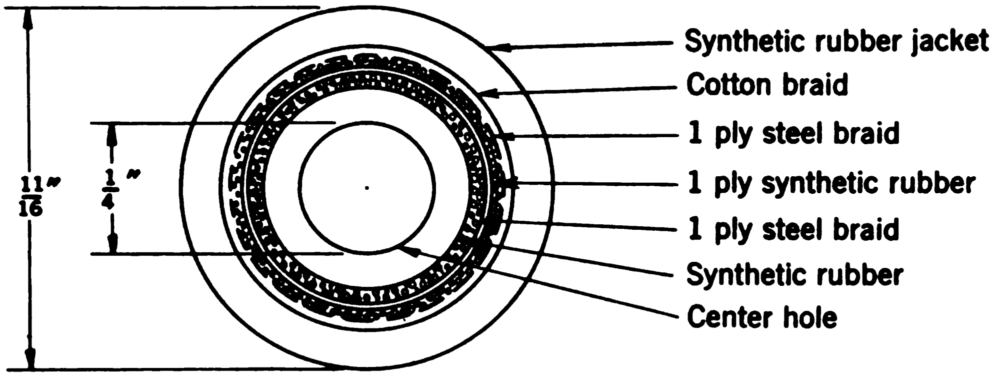
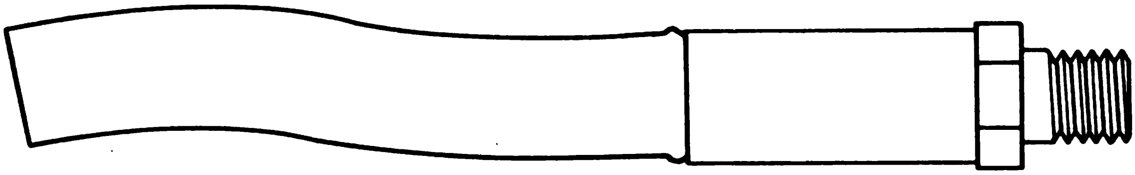


Cross sectional view of flexible cable showing lamination of materials
Scale=3 times actual size



Profile view of flexible cable and coupling
Scale=actual size

Figure 1. - Cross section of rubber-jacketed tubing and piece of tubing with coupling attached.

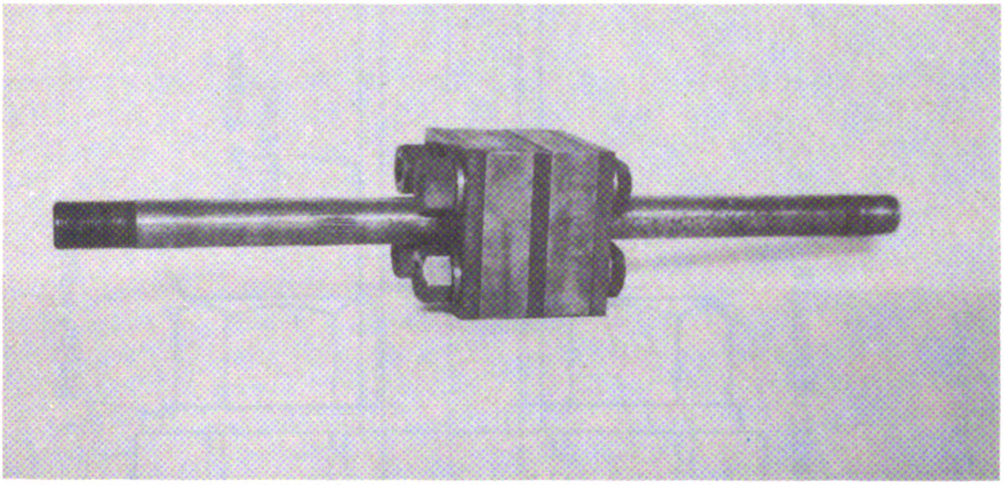


Figure 2. - Insulating coupling assembled.

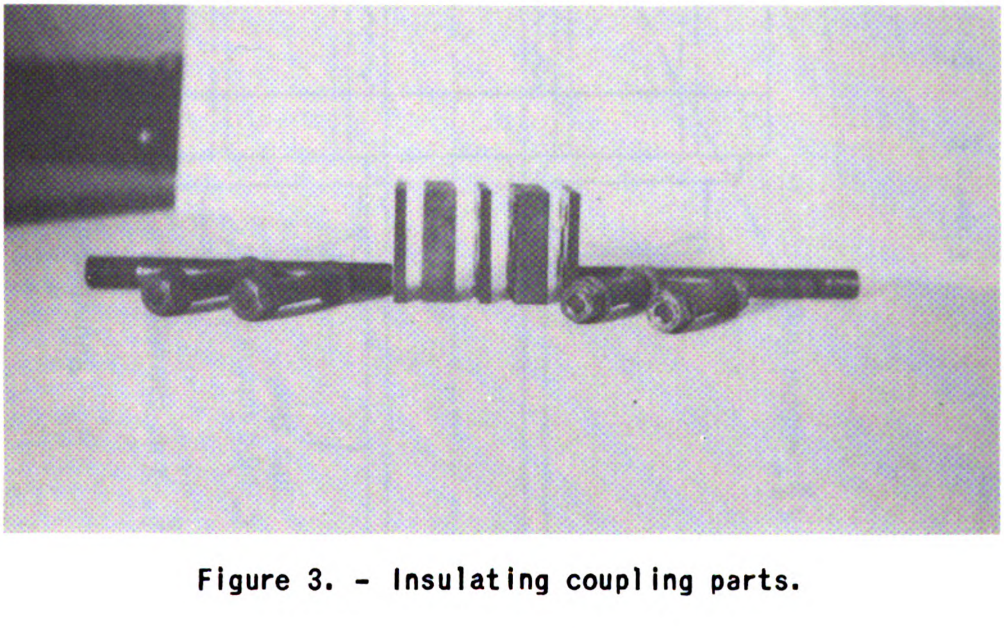
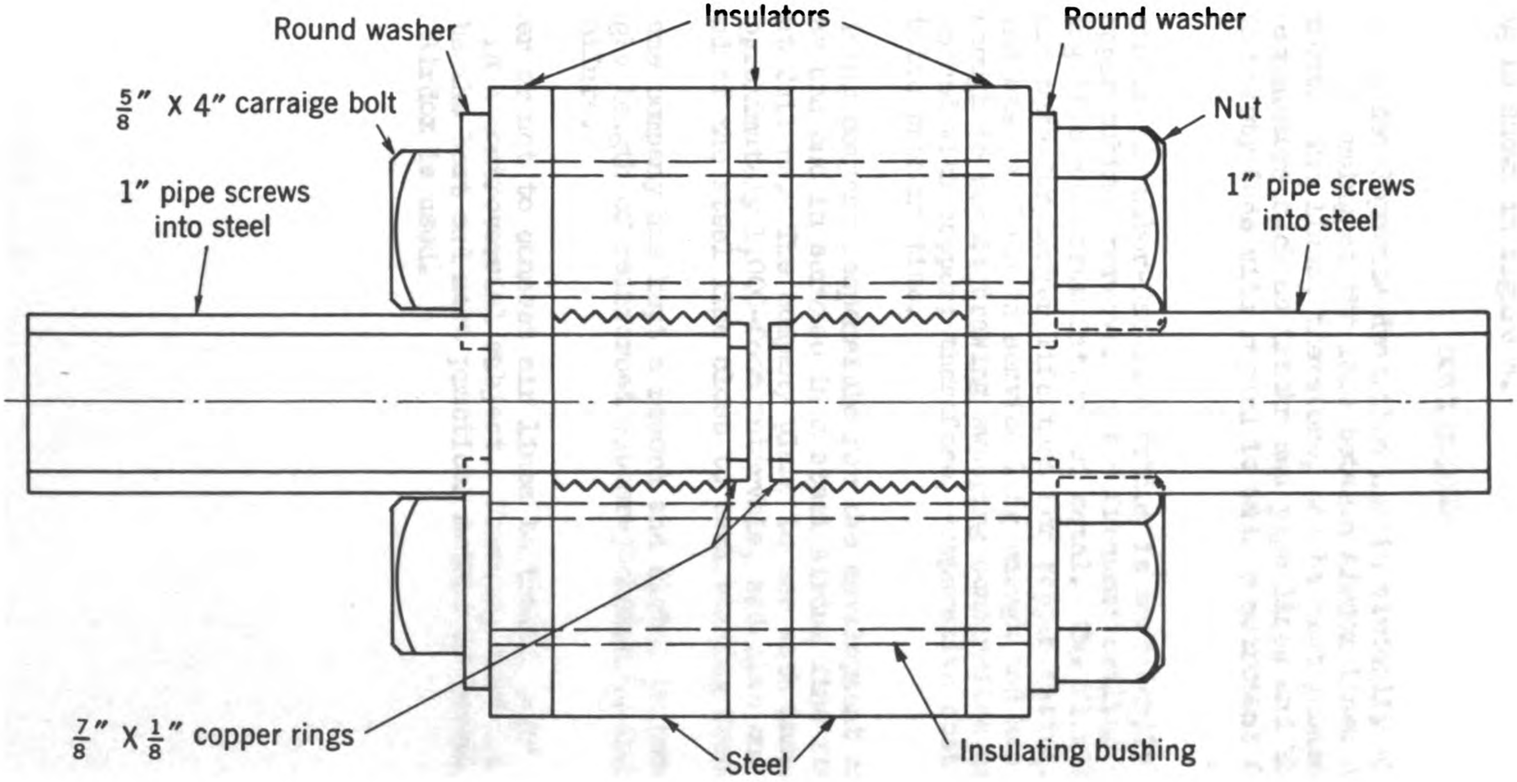


Figure 3. - Insulating coupling parts.


Round washer
Insulators
Round washer
$\frac{5}{8}$″ X 4″ carraige bolt
Nut
1″ pipe screws into steel
1″ pipe screws into steel
$\frac{7}{8}$″ X $\frac{1}{8}$″ copper rings
Steel
Insulating bushing

Scale actual size

Figure 4. - Cross section of insulating coupling.

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A photograph of the assembled coupling is shown in figure 2; the coupling parts are shown in figure 3, and a center cross-section sketch of the coupling is shown in figure 4.

CONCLUSIONS

The recent developments described herein virtually eliminate the possibilities of arcing at the face between Airdox lines and the track or other equipment. The lines, therefore, can be kept insulated or isolated from power conductors, such as tracks and pipe lines and thus comply with the Federal Mine Safety Code with regard to this requirement for Airdox installations.

The reinforced rubber-jacketed tubing is more easily coiled and uncoiled than the copper tubing; moreover, after frequent coiling and uncoiling of the copper tubing it breaks from fatigue of metal. The flexibility of the rubber tubing should make for longer life than for copper tubing. However, such rubber tubing has not been in service long enough and has not been used extensively enough to permit drawing sweeping conclusions as to its probable life as compared with copper; therefore, comparative cost estimates cannot be given at the present time.

The mining company responsible for the development of the insulating coupling has had one in service in a steel Airdox line for a considerable time without failure. The company plans to use such insulators in the air lines at approximately 1,000-foot intervals, and also one will be inserted near the end of the steel line close to each working face.

The same company has kept a record and claims to have broken 4,000 holes with a single length of reinforced rubber-jacketed tubing without a tubing or coupling failure.

Whether or not to connect air lines to tracks, pipe lines, or other power conductors is a controversial subject. However, these recent developments appear to be the best and most practical method of preventing arcing at the face where Airdox is used.

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